

UNCLASSIFIED

AD NUMBER

AD070642

CLASSIFICATION CHANGES

TO: UNCLASSIFIED

FROM: CONFIDENTIAL

LIMITATION CHANGES

TO:

Approved for public release; distribution is
unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies
and their contractors;
Administrative/Operational Use; APR 1955. Other
requests shall be referred to Office of Naval
Research, Washington, DC 20350.

AUTHORITY

30 APR 1967, DoDD 5200.10 gp-4; onr ltr 28 jul
1977

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

UNCLASSIFIED

AD _____

*Reproduced
by the*

**ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA**



**DECLASSIFIED
DOD DIR 5200.9**

UNCLASSIFIED

AD 70642

Armed Services Technical Information Agency

Reproduced by
DOCUMENT SERVICE CENTER
KNOTT BUILDING, DAYTON, 2, OHIO

Because of our limited supply, you are requested to
RETURN THIS COPY WHEN IT HAS SERVED YOUR PURPOSE
so that it may be made available to other requesters.
Your cooperation will be appreciated.

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA
ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED
GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS
NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE
GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE
SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY
IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER
PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE,
USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

ROBERT E. FULTON, JR.
NEWTOWN, CONNECTICUT

REPORT NUMBER : B(I,II,III,IV),
Nonr. 1126(00).

15 April, 1955.

SECTION I

REPORT

on

OPERATIONAL FEASIBILITY TESTS
OF "SKYHOOK" TECHNIQUE FOR IN-
FLIGHT PICK-UP OF MEN AND MA-
TERIALS WITH HIGH PERFORMANCE
AIRCRAFT

under

OFFICE OF NAVAL RESEARCH
CONTRACT Nonr. 1126(00)

CONFIDENTIAL
SECURITY INFORMATION

This document contains information
affecting the National defense of the United States
within the meaning of the Espionage Laws, Title 18,
U.S.C., Sections 793 and 794. Its transmission or
the revelation of its contents in any manner to an
unauthorized person is prohibited by law.

NOTICE: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE
NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING
OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794.
THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN
ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

REPORT NUMBER B (I,II,III & IV) Nonr. 1126(00).

DATE 15 April, 1955.

S E C T I O N I

REPORT

on

OPERATIONAL FEASIBILITY TESTS
OF "SKYHOOK" TECHNIQUE FOR IN-
FLIGHT PICK-UP OF MEN AND MA-
TERIALS WITH HIGH PERFORMANCE
AIRCRAFT

under

OFFICE OF NAVAL RESEARCH
CONTRACT Nonr. 1126(00)

ROBERT E. FULTON, JR. NEWTOWN, CONNECTICUT.

SECURITY INFORMATION

This document contains information
affecting the National defense of the United States
within the meaning of the Espionage Laws, Title 18
U.S.C. Sections 793 and 794. Its transmission or
the revelation of its contents in any manner to an
unauthorized person is prohibited by law.

55AA-43341-SCA-CY14

THIS REPORT COMPILED BY

ROBERT E. FULTON, JR.

AS A RESULT OF WORK BY
THE FOLLOWING GROUP:

Robert E. Fulton Jr.

Robert E. Fulton, Jr., Chairman

Oscar F. Alvarez

O. J. Alvarez

Leopold Godowsky

Leopold S. Godowsky

Karl K. Schakel

Karl K. Schakel

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT No. B (I) Nonr. 1126(00). DATE 15 April, 1955. PAGE B.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

INDEX, SECTION I.

S U B J E C T	P A G E
<u>SECTION I</u>	
Definition of SKYHOOK Technique	1
Purpose of Report	3
Results	4
Operational Photo-sequence	5
Typical pick-up path of load	13
Typical pick-up "G" loads	15
Conclusion	17
Recommendation	18 & 23
Totally Air-Operated KIT	19
Air-Supplied KIT	20
Air-Sea Rescue Operation	21
Surface Vessel Operation	22
Index to Sections II, III and IV *	24

* Section IV is a 16mm kodachrome motion picture film taken during conduct of Operational Feasibility Tests at NAAS, El Centro, Calif.

"SKYHOOK" TECHNIQUE

Assignment calls for development of a method by which IN-FLIGHT-PICK-UP of men and materials can be accomplished with high-performance aircraft.

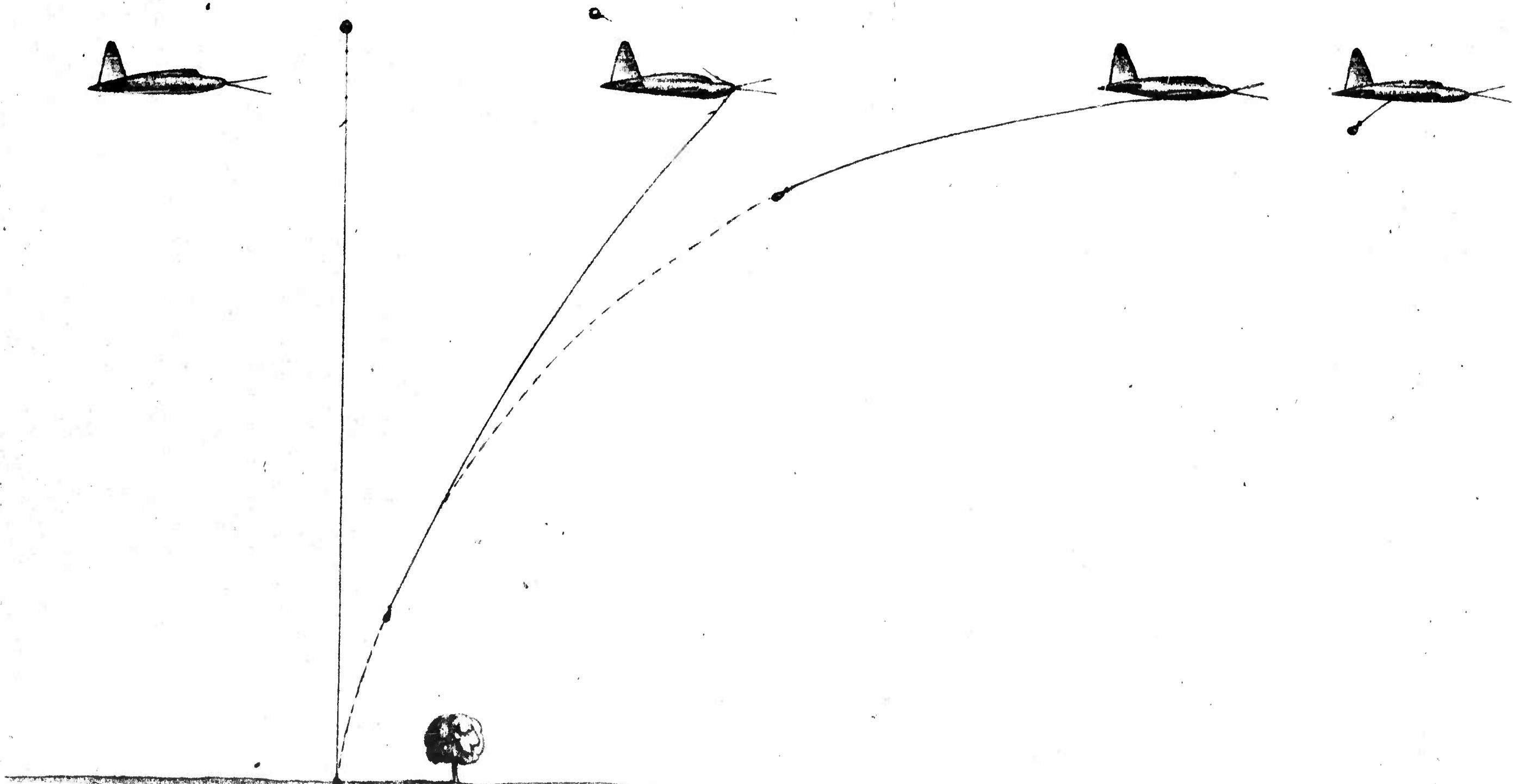
One such method is the SKYHOOK TECHNIQUE which works as follows:

1. Balloon (or other lifting device) supports top end of a line approximately 500 feet above ground.
2. Load is attached to bottom of line.
3. Aircraft intercepts near top of line with "yoke" mounted on nose.
4. Load rises almost vertically, gradually alters to horizontal travel.
5. Load is winched into aircraft.

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B(I)N0N2.1126(00). DATE 15 APRIL, 1955 PAGE 2.

REPORT TITLE
HIGH-PERFORMANCE AIRCRAFT PICK-UP,
"SKYHOOK" TECHNIQUE.



① AIRCRAFT IS
EQUIPPED
WITH YODE
ON NOSE.

② BALLOON (OR OTHER
LIFTING DEVICE)
SUPPORTS LINE WITH
LOAD ATTACHED AT
BOTTOM.

③ AIRCRAFT INTERCEPTS NEAR TOP
OF LINE, LOAD RISES ALMOST VERTICALLY.....

④ GRADUALLY CONVERTS
TO HORIZONTAL
TRAVEL.

⑤ LOAD IS
WINCHED
INTO
AIRCRAFT.

CONFIDENTIAL

REF JR.

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B (I) Nonr.1126(00). DATE 15 April 1956 PAGE 3.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

PURPOSE OF REPORT

This Report deals with tests conducted to prove feasibility of this technique.

Three separate test programs have been successfully conducted to date:

1. Initial tests with Contractor-owned and operated very small aircraft and light loads to prove basic theory.
2. "Safety tests" with somewhat larger Contractor-owned and operated aircraft, heavier loads and higher speeds to study motions of picked up load and top end of line to determine if any danger to aircraft might exist when conducting tests with large, higher speed operational equipment.
3. Preliminary large-scale feasibility tests conducted at NAAS El Centro, California, with full scale Navy owned and operated equipment and heavy loads.

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT No. B (I) Nonr.1126(00). DATE 15 April, 1955. PAGE 4.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

RESULTS

All three of these programs have been successfully conducted, the final one achieving the following standard of results:

- * Aircraft: P2V
- * Intercept speed: 125 knots
- * Loads picked up: up to and including 300 pounds.
- * Average G's imposed on load: 7.54 (Minimum 5, maximum 10.2).
- * Duration of maximum G's: $\frac{1}{2}$ second.
- * Minimum altitude of pick-up aircraft need never be below 400 feet.
- * Pick-up path of lead would clear 100 ft. high obstacle less than 100 feet away.
- * No problem encountered intercepting the lift-line with large, operational type aircraft.

In all more than 50 successful pick-ups were accomplished during all three phases of testing.

OPERATIONAL PHOTO SEQUENCE

Accompanying pictures were taken during operational feasibility testing at NAAS El Centro, illustrate a typical pick-up operation



RENDZVOUS

(P2V)

CONFIDENTIAL



APPROACH

(500 foot altitude)



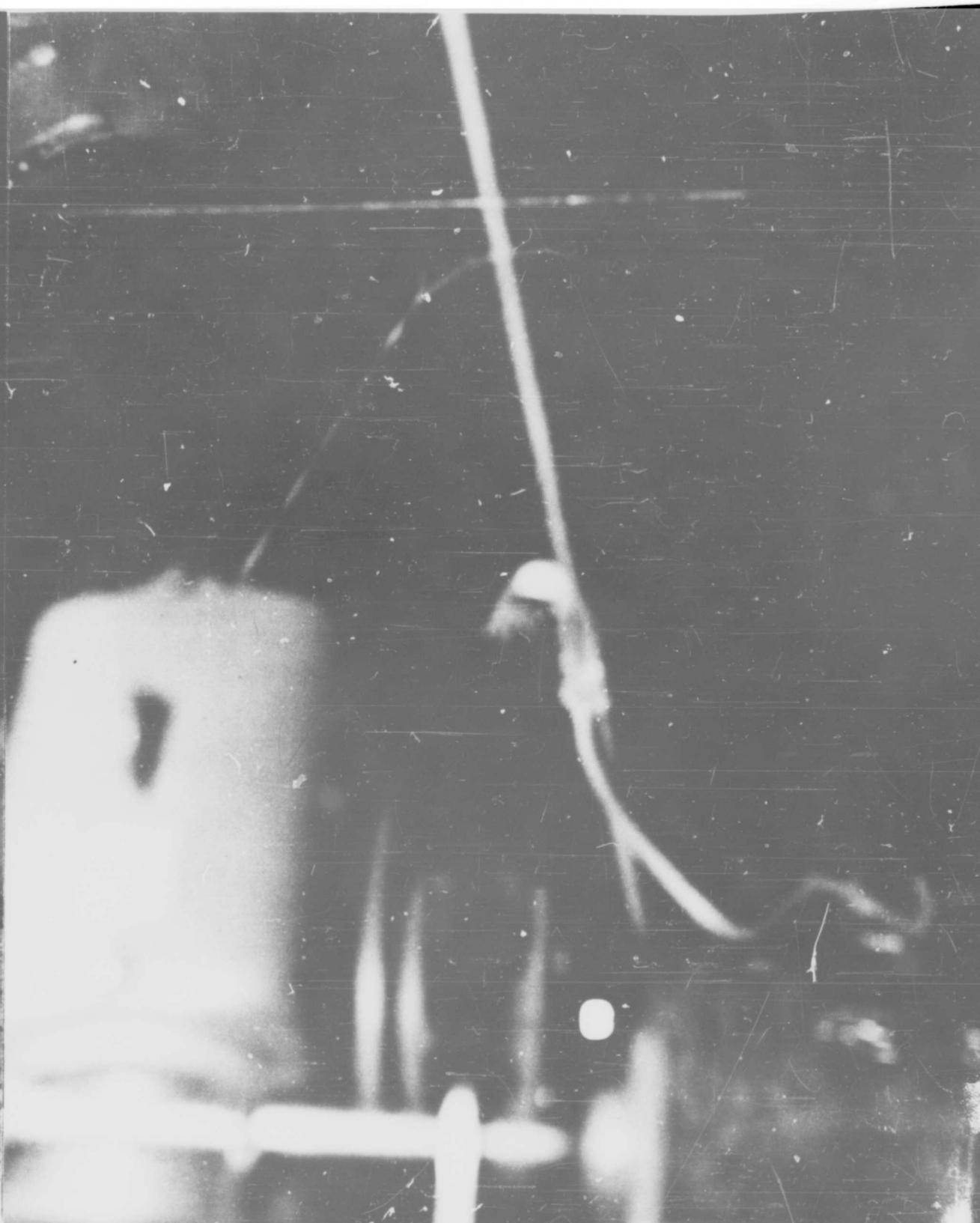
INTERCEPT

(125 knots)



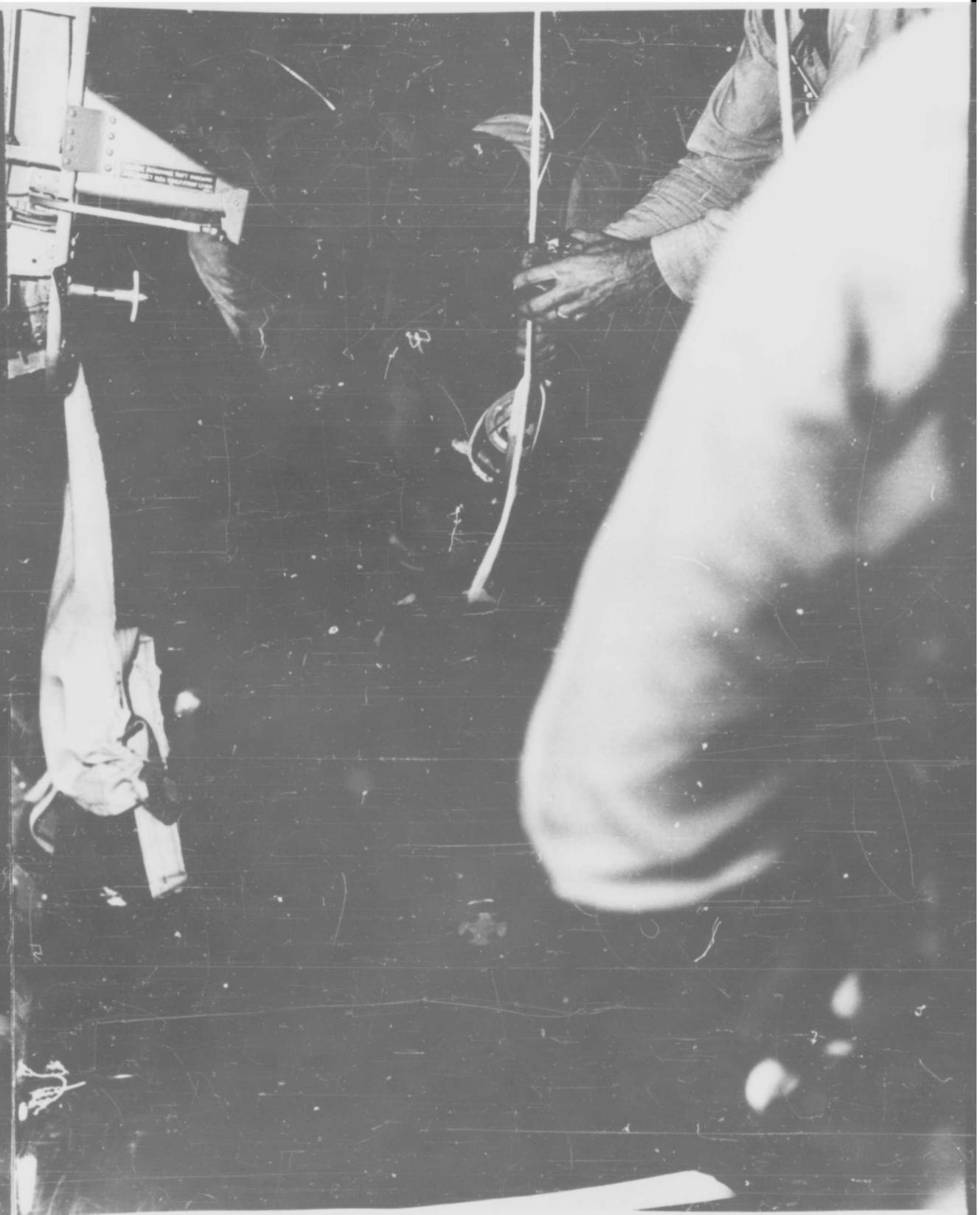
"LOAD AWAY"

(300 pounds)



HAUL IN

(1½ minutes)



ABOARD

RETURNING TO BASE

(Up to 2,000 miles)

CONTINUED

TYPICAL PICK-UP PATH OF LOAD

Accompanying typical curve is taken directly from motion picture film recording path of 200 pound load picked up with 500 foot lift-line at aircraft speed of 125 kncts

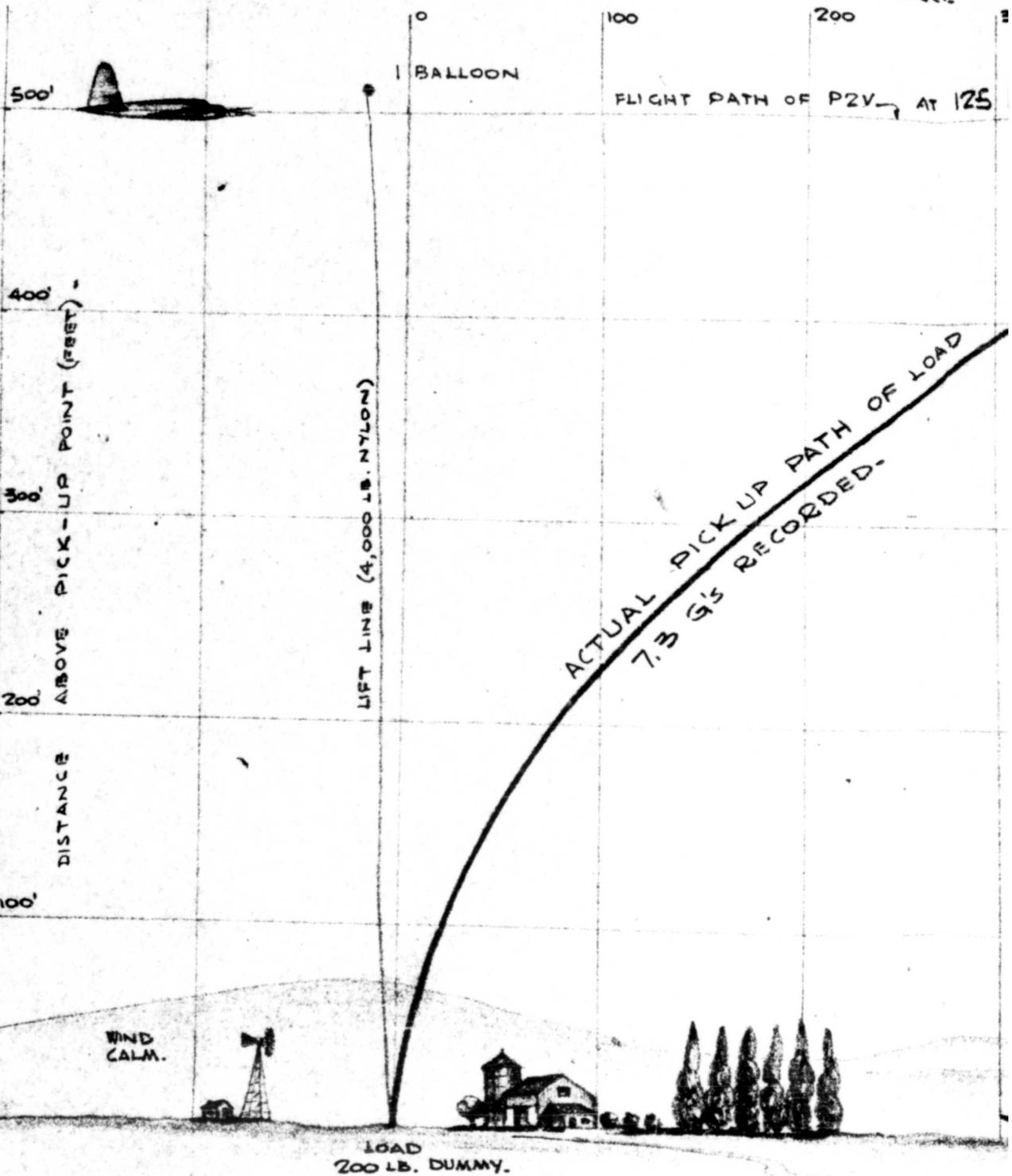
ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT No. B(I) NON R.1126(00) DATE 15 APRIL, 1955 PAGE 14.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

LOAD PICK-UP PATH FROM MOTION PICTURE.

HORIZONTAL DISTANCE FEET



KEYHOOK.

URE.

DANCE FROM PICK-UP POINT. (FEET) -

300

400

500

1000
800
600
400
200
0

PICKUP SK 13,
22 NOV., 1954.
PHOTOGRAPHED
BY CAMERA III,
64 FRAMES /SEC.

AT 125 KNOTS -

" LOAD

250 FT.

COMPUTED
STABILIZED ALTITUDE
OF LOAD. (6,000
FT. FROM PICK UP.)

175 FT.

COMPUTED LOW POINT
OF LOAD PATH
(2,400 FT. FROM PICKUP)

GRID IS DRAWN IN PLANE OF LOAD FLIGHT PATH,
BUILDINGS, TREES, AIRCRAFT.

CONFIDENTIAL

REF JR.

COMPARATIVE "G" LOADS, PICK-UP vs PARACHUTE

Full scale pick-ups produced "G" loads ranging from 5.0 to 10.2 G's (most of them were approximately 7.5) with maximum duration of less than $\frac{1}{2}$ second.

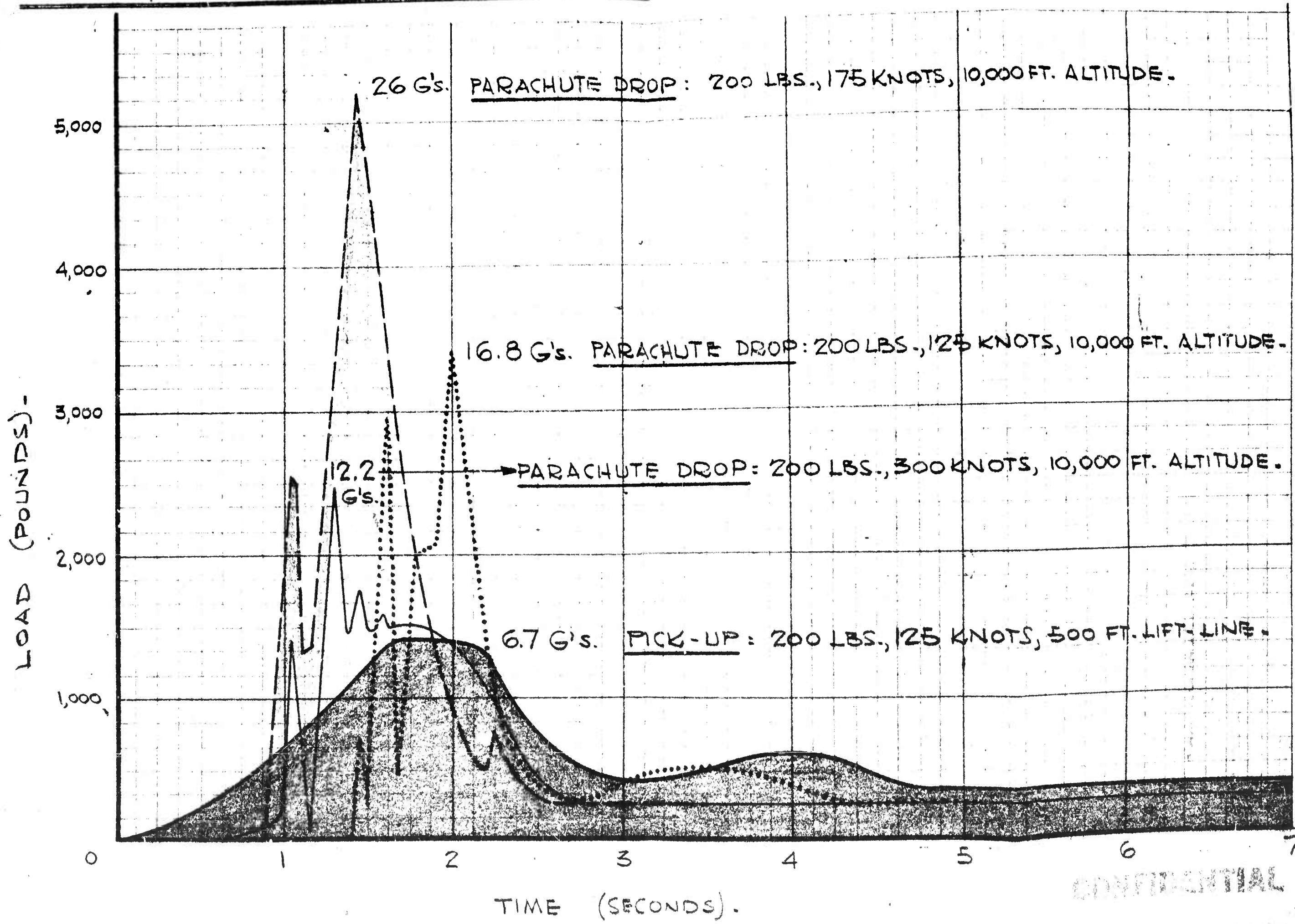
These are well within the physical loads which a human can withstand.

This is graphically demonstrated by accompanying direct comparison of SKYHOOK pick-up load curve and those of several typical parachute jumps

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT No. B(I) NonR. 1126(00) DATE 15 APRIL 1955 PAGE 16.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP.
PARACHUTE VS PICK-UP G's.



ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B (I) Nonr.1126(00). DATE 15 April, 1955. PAGE 17.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

CONCLUSION

The SKYHOOK technique has proven that it can be used for full-scale pick-up work with operational type aircraft.

This technique has demonstrated the important advantages that it can :

1. Perform reliably
2. Be carried out swiftly
3. Be accomplished with only one aircraft (large or small)
4. Does not require much equipment or training.

RECOMMENDATION

For operational service, pick-up equipment should be in KIT FORM so that where desirable operation can be controlled from the rescue aircraft. (Party being picked up would have only to proceed to bottom of lift-line and get into harness or bag.)

There would also be cases, however, where control of the equipment from below would be preferable (such as on shipboard).

Accompanying sketches indicate form in which such KITS are conceived and can be operated under various types of conditions

RECOMMENDATION continued
on Page 23.

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B(I) NNR 1126 (06)

DATE 15 APRIL 1955 PAGE 19.

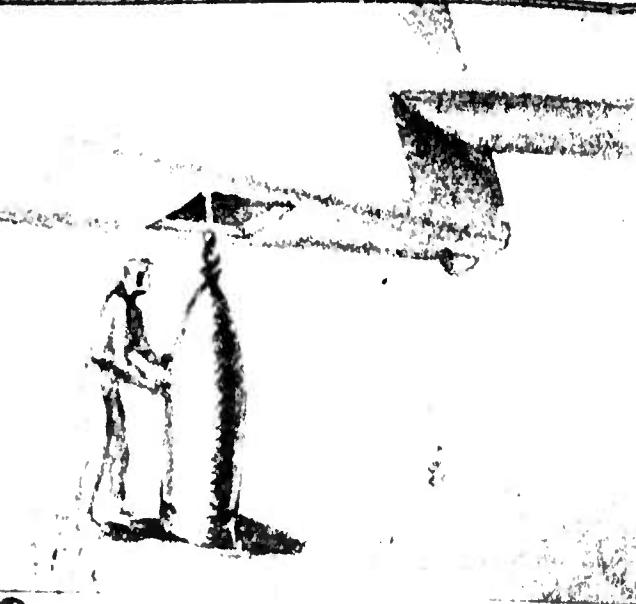
REPORT TITLE HIGH PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

TYPE-A KIT-
TOTALLY AIR-OPERATED KIT FOR USE WHERE QUICKEST FORM OF PICKUP IS ESSENTIAL.

PRELIMINARY EXPERIMENTS IN RELEASE OF FULLY-INFLATED BALLOONS FROM IN-FLIGHT AIRCRAFT (125 KNOTS) HAVE BEEN REPEATEDLY SUCCESSFUL, THEREBY PROVING THE FEASIBILITY OF THIS PROPOSAL.

BECAUSE ITS MASS IS SO SMALL, BALLOON STANDS STILL IN AIR VIRTUALLY INSTANTANEOUSLY UPON RELEASE, THUS AVOIDING SUBJECTION TO STRONG AIR FORCES.

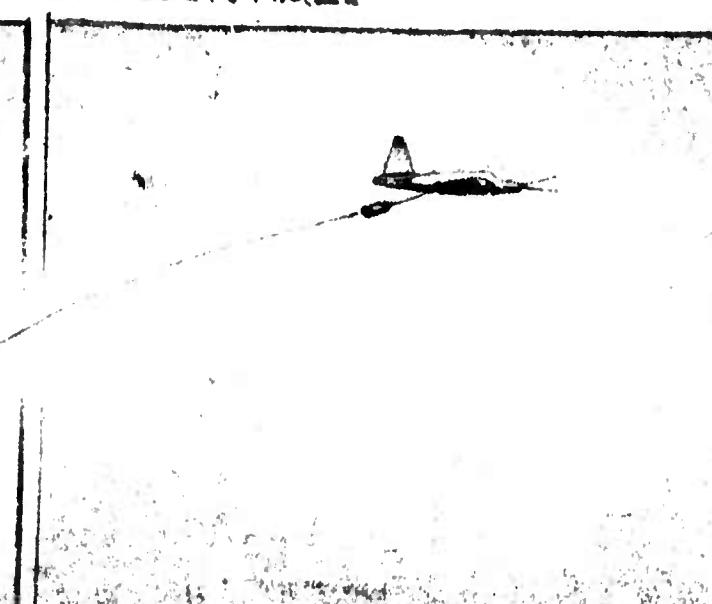
INERTIA OF LIFT-LINE IS ALSO NEGLIGIBLE EXCEPT AT BOTTOM WHERE HARNESS (OR BAG) IS ATTACHED. THIS IS ELIMINATED BY USE OF SMALL PILOT-PARACHUTE WHICH SWINGS INTO ACTION AS SOON AS BALLOON IS RELEASED FROM AIRCRAFT.



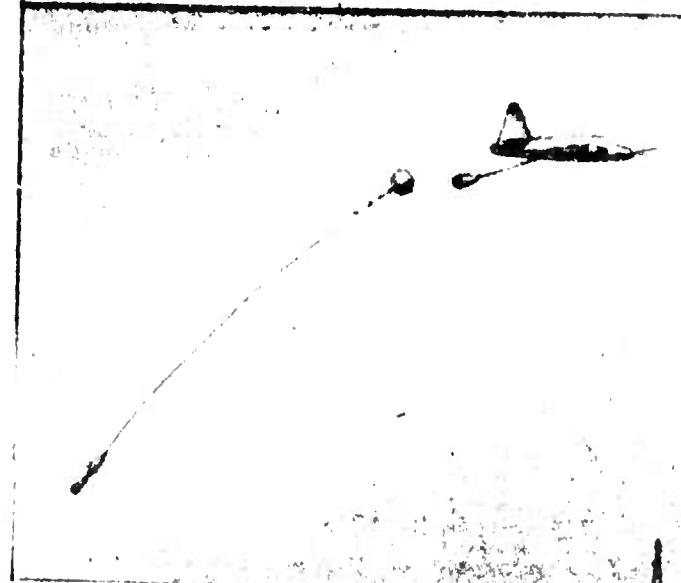
① LOADING KIT(S).
(ESTIMATED WEIGHT: 30 LBS.)



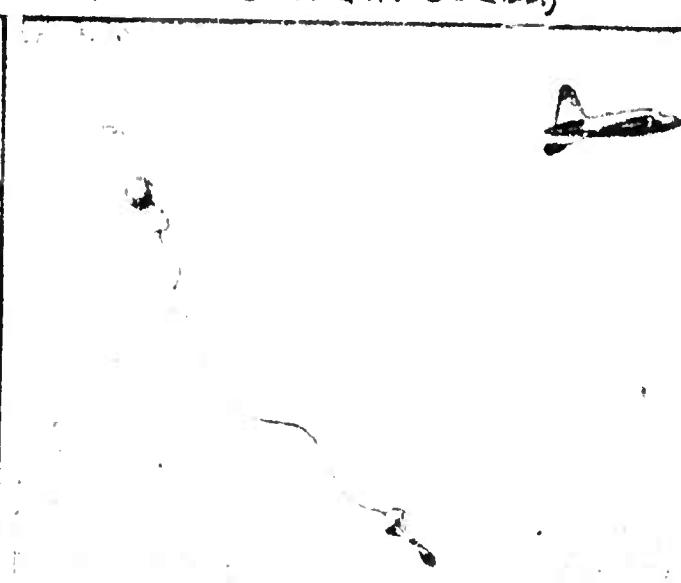
② STREAMING LIFT-LINE.



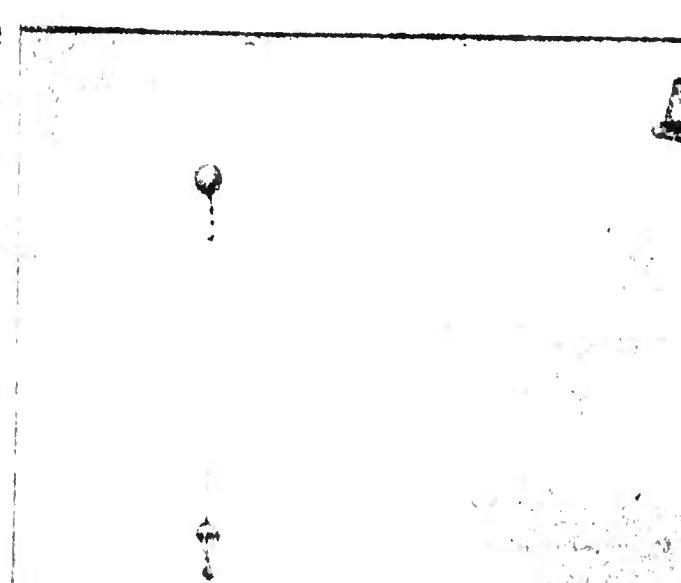
③ STREAMING BALLOON IN CONTAINER.



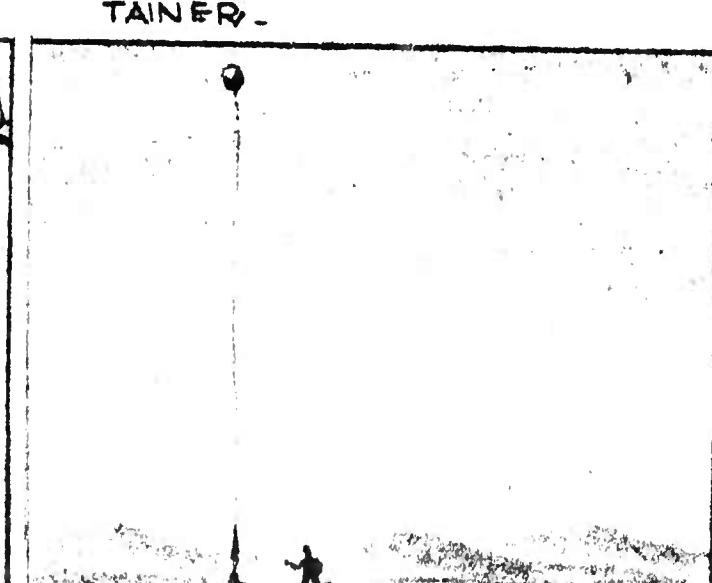
④ RELEASING BALLOON FROM CONTAINER. (SEE ABOVE NOTE)



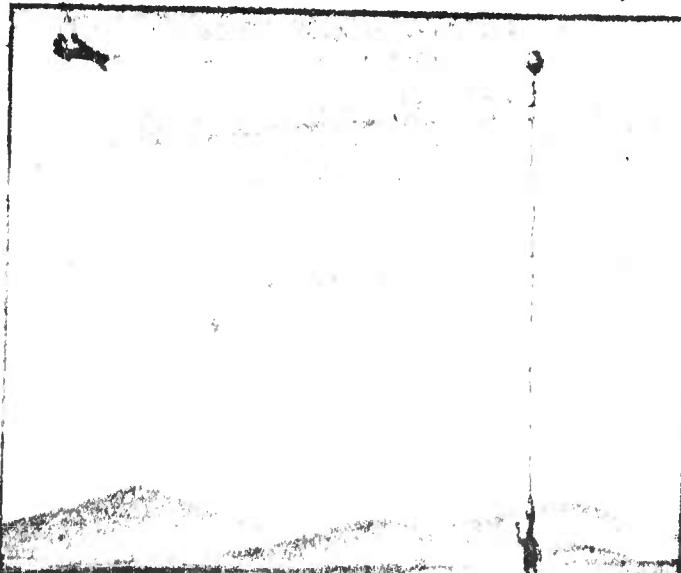
⑤ SMALL PARACHUTE ABSORBS INERTIA OF HARNESS.



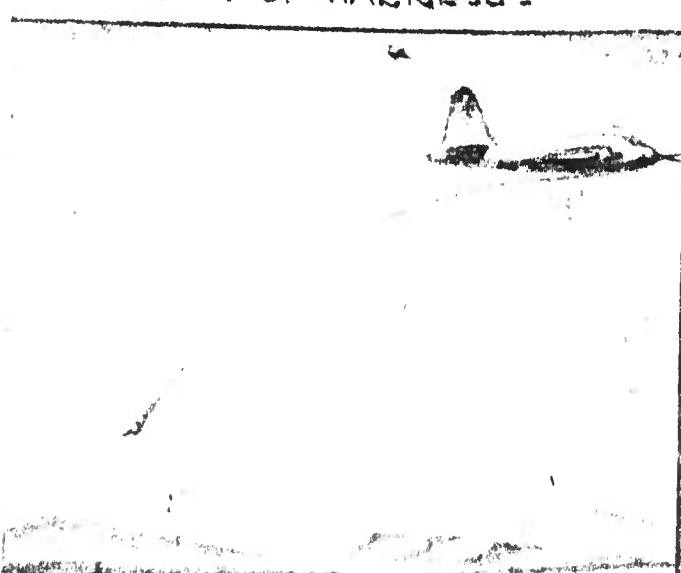
⑥ LIFT-LINE DESCENDING.
(CONTAINER PULLED INTO AIRCRAFT).



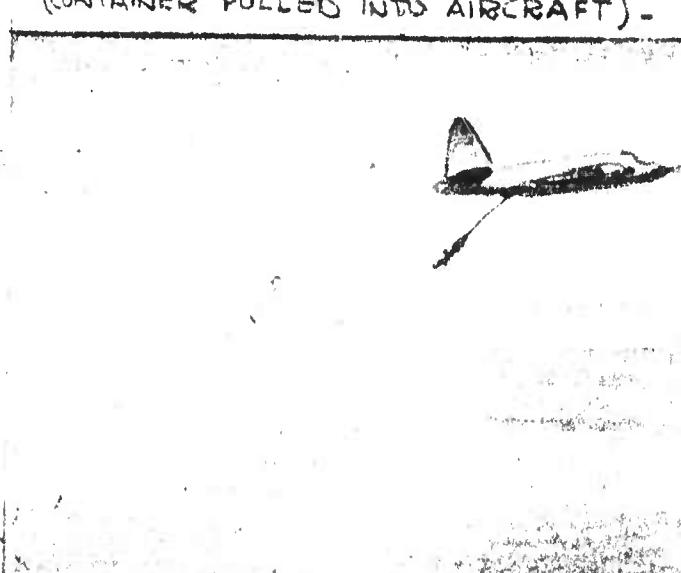
⑦ PROCEEDING TO FULLY RIGGED LIFT-LINE. (EASY TO FIND).



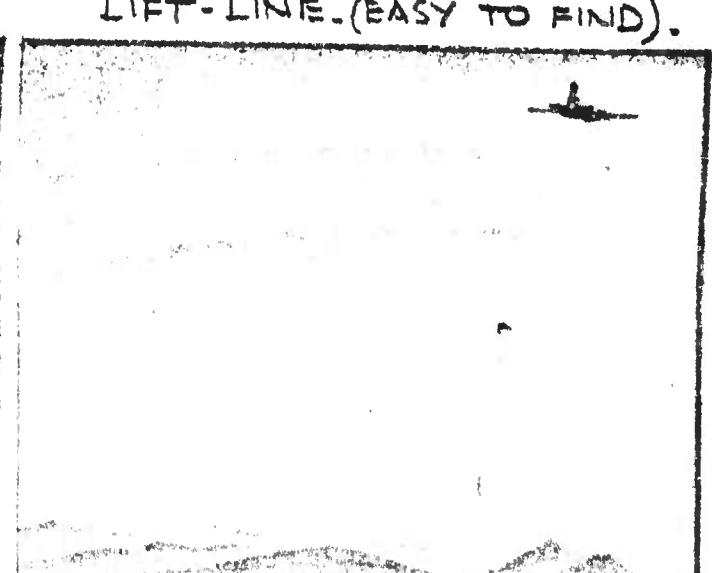
⑧ GETTING INTO BAG (OR HARNESS)



⑨ PICKING-UP.



⑩ HAULING IN.



⑪ RETURNING TO BASE--
(WITH ALL EQUIPMENT)

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. 3(I) NONR. 1126(00) - DATE 15 APRIL 1955 PAGE 20.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK

TYPE - B KIT.

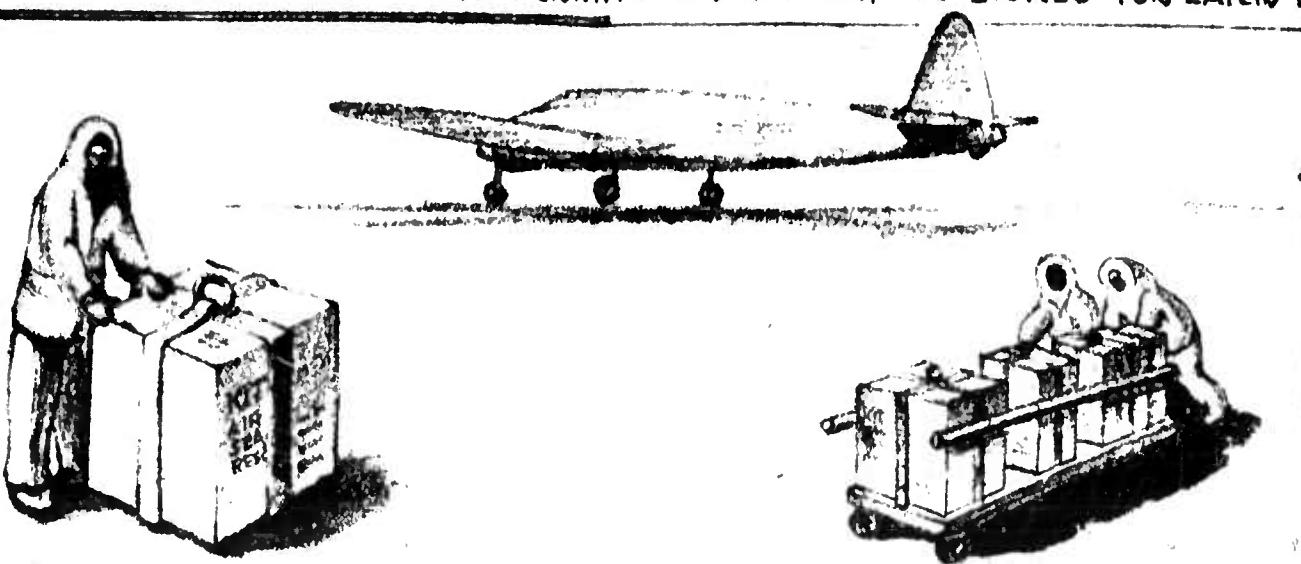
AIR SUPPLIED KIT FOR USE WHERE TIME PERMITS OR KIT MAY BE STORED FOR LATER USE

EQUIPMENT FOR THIS KIT IS ESSENTIALLY
REFINEMENT OF UNITS USED DURING THE
OPERATIONAL FEASIBILITY TESTS.

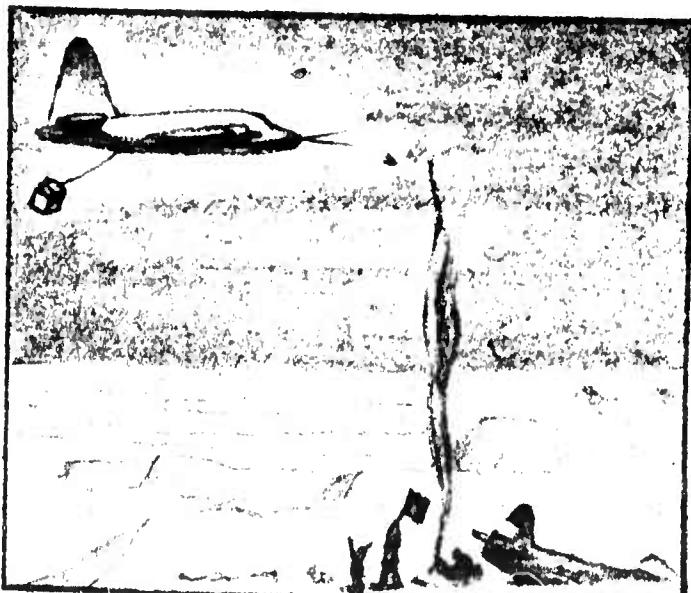
COMPLETE KIT WILL CONTAIN BALLOONS,
HELIUM CYLINDERS, CONTROL VALVE AND
MANIFOLD, LIFT-LINE COMPLETE WITH
"KNOTS", BUFFERS, HARNESS (OR BAG)
AND ASSOCIATED HARDWARE.

DROP-CHUTE WILL CLIP ON OUTSIDE OF
KIT.

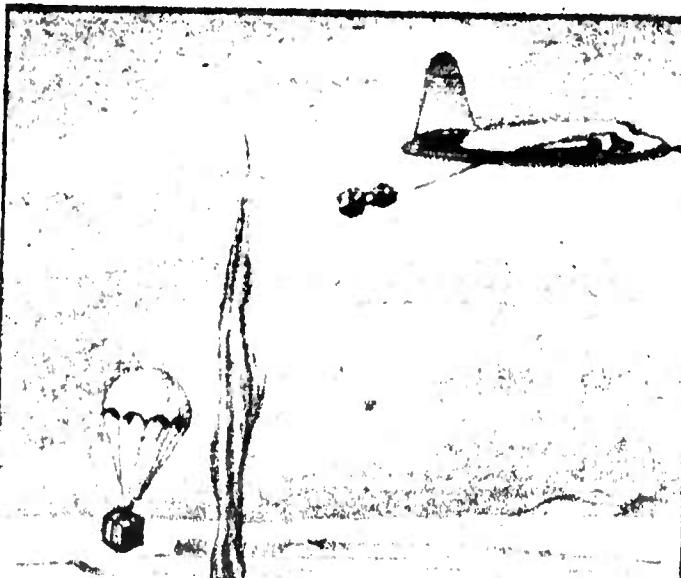
KITE-KITS SHOULD ALSO BE MADE
UP FOR USE IN STRONG WINDS.



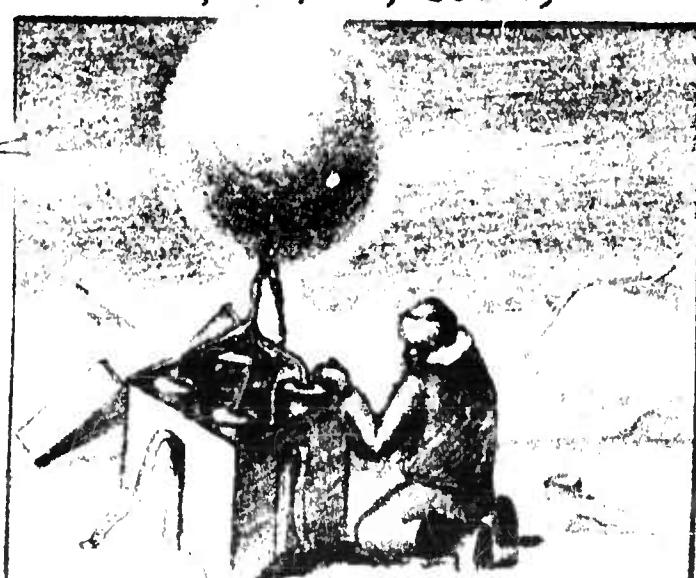
CONFIDENTIAL



② EJECTING KIT.



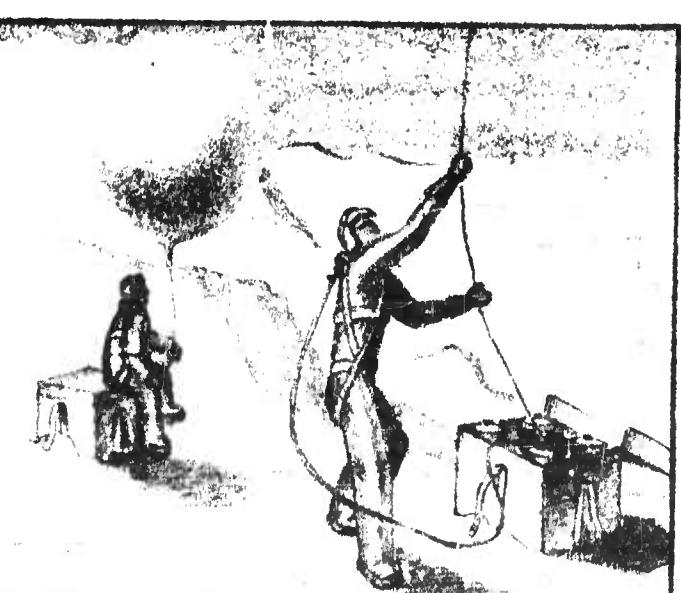
③ PARACHUTE- DESCENT.



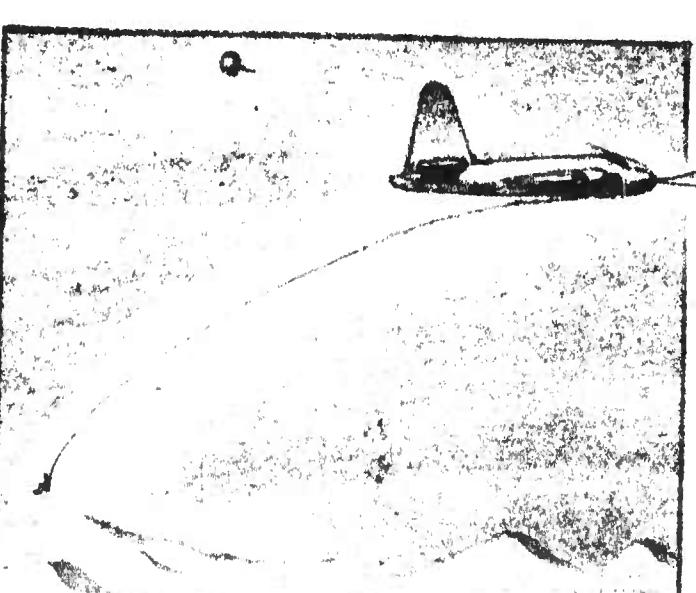
④ SINGLE- OPERATION INFLATION.



⑤ INTO HARNESS (OR BAG), BALLOON
& LIFT-LINE ALREADY ATTACHED.



⑥ PAYING OUT LIFT-LINE.



⑦ PICK-UP & HAUL IN (MAXIMUM
TOTAL OF 3 MINUTES PER MAN).

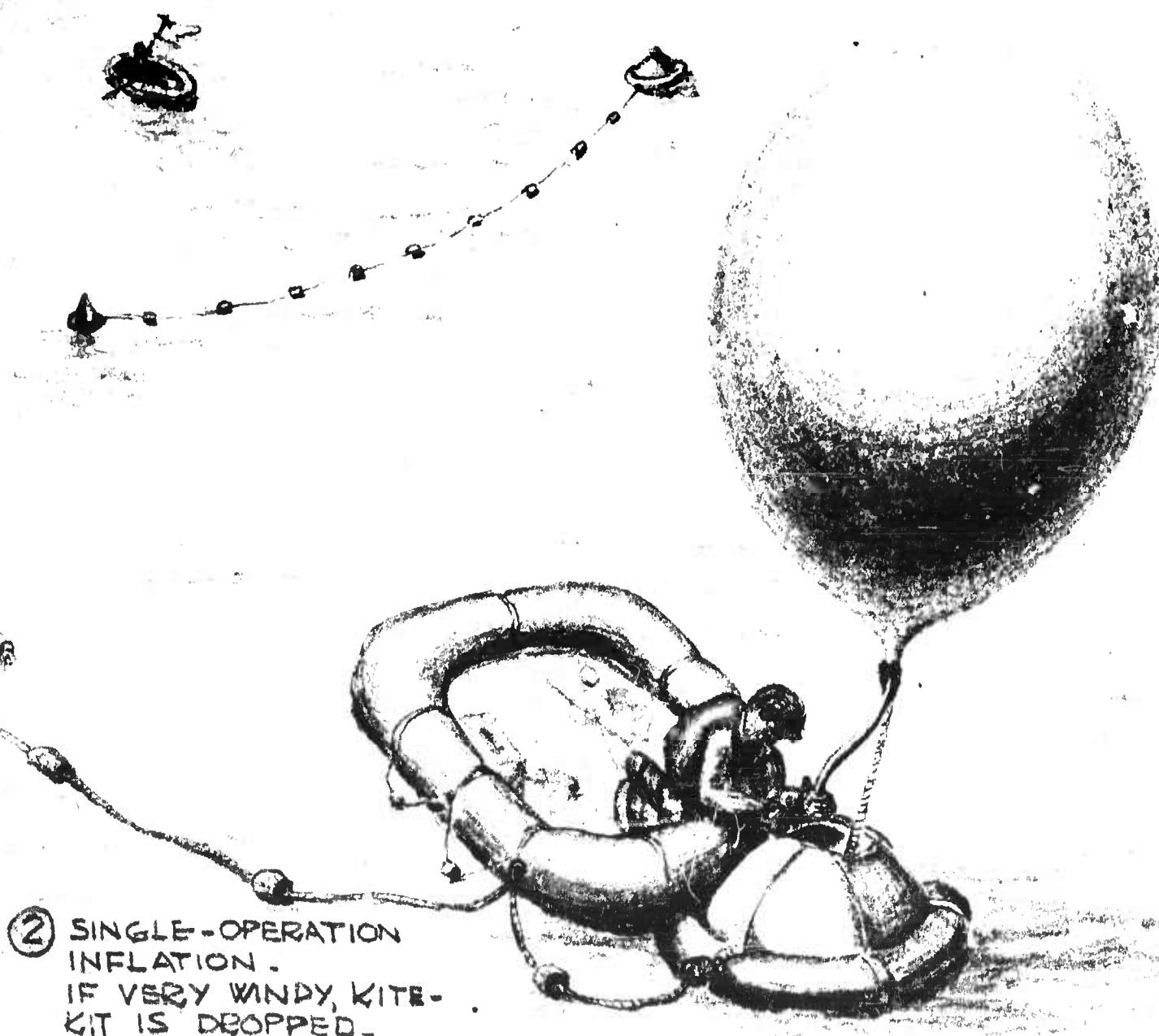
ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B(I) NOND 1126 (00) DATE 15 APRIL, 1955 PAGE 21

REPORT TITLE HIGH PERFORMANCE AIRCRAFT PICK UP, SKYHOOK
TYPE AOR 3 KIT FOR AIR-SEA RESCUE OPERATIONS.

① AIRCRAFT FLIES TO LEeward
OF RAFT, DROPS CORK-FLOATED
NYLON LINE WITH BUOY AND
FLOATING KIT ON OPPOSITE ENDS.

RAFT DRIFTS INTO LINE -



② SINGLE-OPERATION
INFLATION.
IF VERY WINDY, KITE-
KIT IS DROPPED -

④ PICK-UP, HAUL IN
AND RETURN TO
BASE -

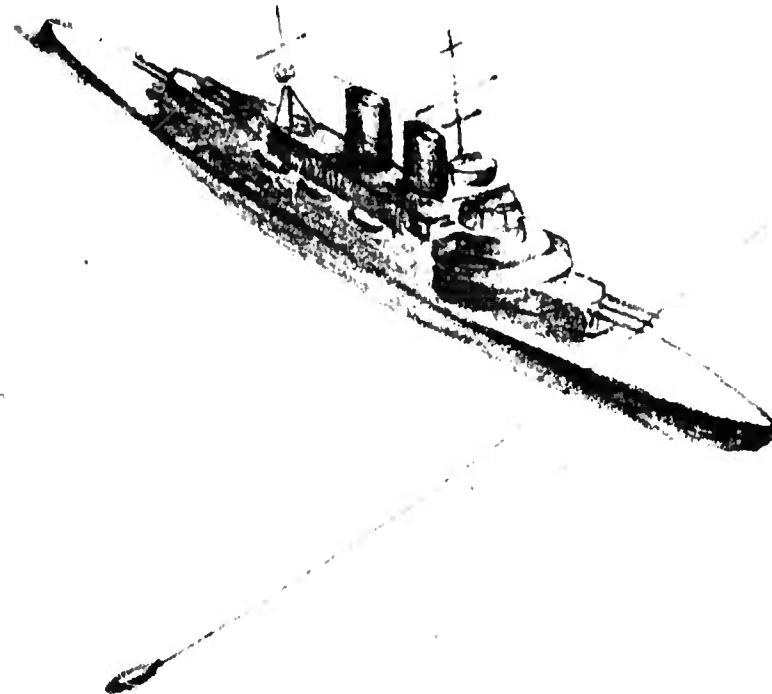
③ INTO HARNESS -

CONFIDENTIAL

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT No. B (I) NONR 1126(00). DATE 15 APRIL 1955 PAGE 22.

REPORT TITLE HIGH PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK
TYPE B KIT FOR SURFACE VESSEL OPERATIONS.



③

MESSAGES OR PERSONNEL
CAN BE PICKED UP FROM
VESSEL.
BALLOON IS USED BY SHIP
TRAVELLING WITH WIND.



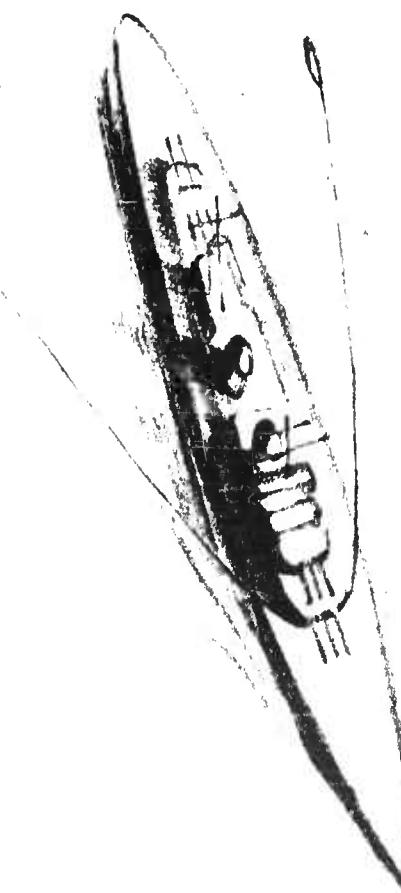
① (ABOVE)

FOR DELIVERY OF MESSAGES,
NYLON LINE IS FLOWN LOW
OVER BOW OF SURFACE VESSEL.

② (RIGHT)

BOTH ENDS OF LINE ARE
ATTACHED TO IDENTICAL
FLOATS, ONE CONTAINING
PAPERS.

WHEN DROPPED, LINE
STREAMS AFT FROM BOTH
SIDES OF VESSEL, CONTAINERS
ARE READILY HAULED ABOARD.



④ (RIGHT)

WHEN SURFACE VESSEL
IS TRAVELLING TO WINDWARD,
KITE MAY BE USED.



ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B (I) Nonr.1126(00). DATE 15 April, 1955. PAGE 23.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

RECOMMENDATION continued.

Development of operational equipment in final form is largely a matter of refining the test units which have proven their ability to work but can now be brought into better relative proportion as a result of the test experience gained.

The form of the above-outlined KITS, along with standardized hardware (yoke, winch, etc.) for use in the aircraft, should be established and tested.

Tests should include large number of dummy pick-ups and simulation of all possible operational situations before personnel pick-ups are accomplished.

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B (I) Nonr.1126(00). DATE 15 April 1955 PAGE 24.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

INDEX, SECTIONS II, III & IV.

S U B J E C T	P A G E
<u>SECTION II</u>	
Section II Note	A
Section II Index	B
TEST LOCATION AND CONDITIONS, GENERAL	1
AIRCRAFT AND AIRBORNE EQUIPMENT	
Aircraft	9
Yokes	14
Beam	23
"Eye"	25
Winches	30
Bridle	36
Crook	40
Snatch Block	44
PICK-UP EQUIPMENT	
Loads	46
Harness	51
Lines	53
"Knots" and couplings	56
Fittings	63
Markers	65
Balloons	68
OPERATING PROCEDURES	
Pilotage, approach	76
Action of Lift-Line	85
Reel-in procedure	87
Reel-in procedure comment	97
Lift-line clamp sketch	98
"Clamp-knot"	99
RECORDING AND MEASURING EQUIPMENT	
Wind	101
Photographic equipment	103
Angle of Lift-line	110
Path of picked-up loads	112
Path of picked-up loads comment	130
Brinnel blocks	132
Tensiometer, recording	134
"G" loads	136

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B (I) Nonr.1126(00). DATE 15 April, 1955. PAGE 25

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

I N D E X, SECTIONS II, III & IV continued.

S U B J E C T

P A G E

SECTION II cont'd.

Graph of Ex-line tape from 200 lb. pick-up	139
Graphs of Ex-line tapes from parachute jumps	141
Pick-up vs parachute G's comment	146
Tabulated test data	147
Comments re initial test phase	148
Comments re safety test phase	149
Resume of operational feasibility tests	153
Detailed operational feasibility test data	154

SECTION III

(Comments and drawings regarding design of test and operational equipment)

Section III note	A
Section III Index	B
Yoke	1
Beam	17
"Eye"	20
P2V Drawing List	26
Drawings of Beam and Yoke	30
Winch	71
Radomes, antennae, etc.	82
Harness and load covering	86
Lines and fittings	89
Line samples	90
"Chinese Finger" samples	91
"Coupling" drawings	93
Clamp	94
Balloons	96
Gas	97
Markers	98
Operational Lift-Line KIT	99
Kite-hook	101
Summary statement	102
Photographic appendix	103
Bibliography	104

ROBERT E.
FULTON, JR.
NEWTOWN,
CONNECTICUT.

REPORT NO. B(I)Nonr.1126(00). DATE 15 April, 1955. PAGE 25.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

INDEX, SECTIONS II, III & IV cont'd.

S U B J E C T

P A G E

SECTION IV

This Section consists of a 16mm Kodachrome motion picture film taken during Operational Feasibility Tests at NAAS El Centro, California.

Running time is approximately 30 minutes.

Material illustrated includes the following:

1. A typical SKYHOOK pick-up operation.
2. Yoke installation on P2V.
3. Winch, crook, snatch-block, clamp-knot, auxiliary winch.
4. Loads and fittings
(Sand bags, dummies, Ex-line tensiometer, Brinnel blocks).
5. Lines, markers, knots
(Tower testing, buffers vs windshield).
6. Balloons and gas
7. Pilotage
(Yoke camera, visibility, vertical and horizontal latitude of intercept).
8. Photographic equipment
9. Paths of picked-up loads